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REM documentation of putative cuticular sense organs of enchytraeids

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Abstract

In enchytraeids, reactions to light, chemicals and mechanical stimuli are known. However, until today no attempt has been made to investigate the external sense organs of enchytraeids, whereas on their bigger relatives, earthworms of the family Lumbricidae, as early as 1895 so-called sensory buds were found. In this contribution the distribution and form of sensory buds in five different species of terrestrial enchytraeids are investigated by means of a Scanning Electron Microscope. Most of these organs were found on the prostomium (including the oral cavity), the first and the last segment. No obvious differences were observed between these species or in comparison to earthworms. In addition, the state of knowledge about these organs in other annelid worms, especially earthworms, is briefly discussed.

Introduction

In enchytraeids, reactions to light, chemicals and mechanical stimuli are known (STEPHENSON 1930). However, until today no attempt has been made to investigate the external sense organs of enchytraeids, whereas on their bigger relatives, earthworms of the family Lumbricidae, as early as 1895 so-called sensory buds were found (LANGDON 1895). Similar structures are also known from other oligochaete families like the Tubificidae (SMITH 1983) whereas the distribution and form of external sense organs are quite different in the annelid leeches (Hirudinea) (ELLIOTT 1987). In this contribution the distribution, form and arrangement of sensory buds on different species of terrestrial enchytraeids are investigated by means of a Scanning Electron Microscope. In addition, the state of knowledge about these organs in other annelid worms, especially earthworms, is briefly discussed.

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Material and Methods

Specimens from different terrestrial species (*Achaeta* sp., *Cognettia sphagnetorum*, *Enchytraeus* cf. *minutus*, *Mesenchytraeus glandulosus*, *Oconnorella cambrensis*), mainly collected at forest sites in Southern Germany, were fixed for 4 h at ambient room temperature with 5 % glutaraldehyde in 0.1 M phosphate buffer (pH 7.4) with 15 % sucrose added. After washing in the same buffer (once every 15 min. for a total of four washes), they were postfixed for 2 h in OsO4 (in the same buffer), then dehydrated in an ethanol series, and air-dried following a short (1–2 min) incubation in hexamethyldisilazane (NATION 1983). Dried specimens were glued to aluminium holders, gold-coated, and examined with a Hitachi S-500 scanning electron microscope. Note: The investigated *Achaeta* species is a new, formally yet undescribed species, described in the Diploma thesis of U. GRAEFE (1972, University of Hamburg) as »*A. affinoides*«, and already mentioned in several publications, see HECK & ACHAZI (this volume).

Results

Besides various simple pores (»openings«), the functions of which remain mainly speculative, structures resembling the lumbricid sensory buds are the most obvious external cuticular organs of enchytraeids. The distribution of these buds is basically the same in various species of different genera (Fig. 1–3): They are very abundant close to the mouth and on the foremost and dorsal parts of the prostomium, where their density can be extremely high (30–60). Only few are located on the following segments, where their number decreases to almost zero. However, often some of these organs are grouped together close to the setal bundles (Figs. 4, 5). Only on the last segment a number similarly high as on the prostomium could be found (Fig. 6). Despite the fact that in some cases (e.g. on the third segment of *C. sphagnetorum* (Fig. 2)) sensory buds seem to form rows there no clear distribution pattern is observable.

Very often the sensory buds consist of an oval or round »knob« from which many (10–100) flexible sensory cilia arise (Fig. 6). In other cases the cilia seem to emerge directly from the cuticle (Fig. 7). The diameter of the knobs is roughly 5 µm and their height can reach approximately 3 µm. The length of the cilia can be very variable: between less than 0.2 µm and, rarely, up to 2 µm. It is possible that some of these differences are caused by the SEM preparatory process (e.g. a damage of the tips of the cilia; Fig. 8). On the other hand, it is also possible that the length of the cilia and the form of the buds indicate the age of the individual organ or worm or the specific function of the respective organ.

Discussion

Despite the fact that cuticular sense organs in earthworms were found as early as 1895 by LANGDON there is some confusion about their distribution. In a recent textbook on earthworm biology, sensory buds are described as being »scattered throughout the epidermis, more numerous on the ventral than on the dorsal surface« (EDWARDS & BOHLEN 1996). However, in an instruction book for student practical courses (PETERS & WALLDORF 1986), the distribution and form of the sensory buds in *Lumbricus*

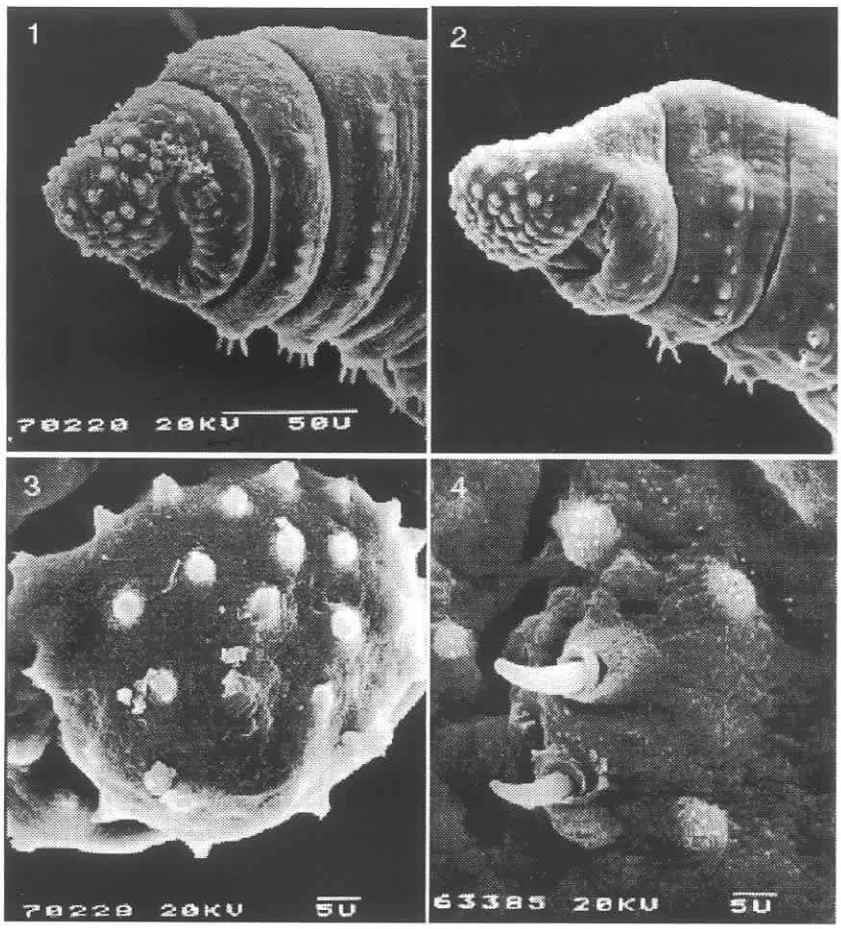

Fig. 1: Prostomium of O. cambrensis, *bar = 50 µm; Fig. 2: Prostomium of* C. sphagnetorum *Fig. 3: Prostomium of* Achaeta sp., *bar = 5µm; Fig. 4: Sense organs around a setal bundle of a juvenile* M. glandulosus, *bar = 5 µm*

terrestris resembles very much the situation found in the various enchytraeid species presented in this contribution. This result is supported by observations in other lumbricid species like *Dendrobaena octaedra* or *Eisenia fetida*, where always numerous sensory buds were found scattered on the prostomium (at least 200–400; especially in or close to the oral cavity) as well as the first and the last segment (AROS et al. 1971, AROS et al. 1978). LANGDON (1895) counted 1900 sensory organs on the prostomium and the first segment of *L. terrestris* (and still 700 on segment 56), which seems to be rather high compared to results of more recent investigations. In any case, the absolute number of organs per segment is higher in earthworms than in enchytraeids due to their larger size. MOMENT & JOHNSON (1979) give an even more detailed overview on the distribution and external structure of these organs of newly hatched and mature compost worms

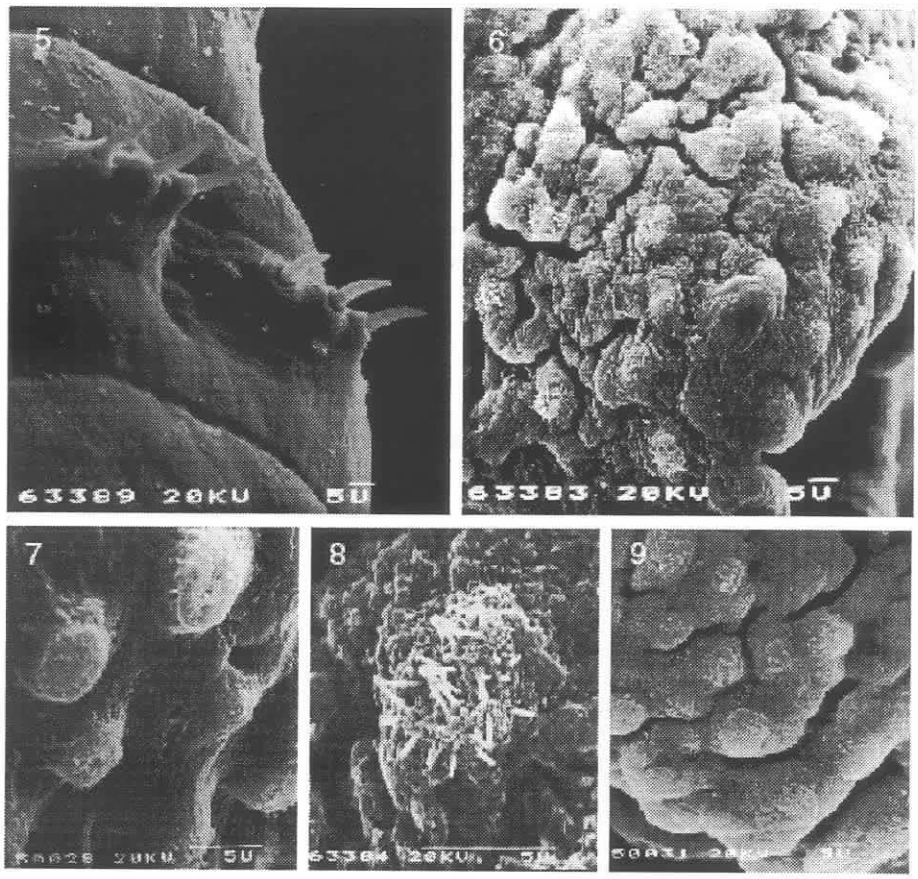

Fig. 5: Sense organs around setal bundles of E. cf. minutus; Fig. 6: Last segment of a juvenile M. glandulosus; *Fig. 7: Individual sensory buds of* C. shagnetorum *and an „opening" of unknown function; Fig. 8: Sensual cilia arising from the cuticle of* M.glandulosus*; Fig. 9: Fissures in the „lower lip" of* M. glandulosus*; all bars = 5µm.*

(E. fetida). Like AROS et al. (1971) they observed that on the segments between the first and last one the sensory organs form a single row aligned with the setae encircling the worm.

Even in limnic tubificid Oligochaeta species like *Tubifex tubifex* or *Limnodrilus hoffmeisteri* the distribution and external structure of sensory buds is roughly comparable to those found in the enchytraeids (SMITH 1983). However, in addition to those organs on the prostomium of the tubificids a compact band of sensory buds was found around the circumference of segments I–III for both species. In the limnic species *Branchiobdella pentodonta*, belonging to the basal oligochaete order Lumbriculida, it is mainly the prostomium which is covered with »sense buttons« (FARNESI et al. 1982). In contrast, in aquatic leeches, belonging to another annelid subclass than the Oligochaeta, the distribution and form of cuticular sense organs seem to be quite different (e.g. DEROSA & FRIESEN 1981, KHAN & EMERSON 1981, ELLIOTT 1987). Apparently the

distribution of cuticular sense organs is quite uniform in two quite distinct families of terrestrial Oligochaeta whereas limnic oligochaetes show some differences and other aquatic annelids have a completely different pattern.

MOMENT & JOHNSON (1979) determined the average diameter of an individual sensory bud on the prostomium as 18 µm in adult *E. fetida*, whereas newly emerged worms have buds only half that size. In *L. terrestris*, the size of an individual bud on the prostomium varies between 5 and 10 mm (PETERS & WALLDORF 1986). The data obtained so far for enchytraeids do not allow to decide whether their organs are also of different size in different age classes. However, number (15–100) and length (up to 2 mm) of sensory cilia seem to be nearly the same in earthworms and enchytraeids.

Lumbricid sensory buds in general (including light sensilla) consist of 16–35 elongated cells (HESSE 1894), terminating in sensory hairs projecting through thin regions of the cuticle, but without an obvious external knob or bud. Later AVEL (1959) confirmed this observation, describing that the cuticular sensory buds in particular consist of a group of elongated cells of which the basal ends extend as sensory axons into the peripheral nerves, while their distal ends give rise to sensory cilia. KNAPP & MILL (1971) and AROS et al. (1971) investigated the fine structure of ciliated sensory cells in the epidermis of *L. terrestris* and *D. octaedra*. They described two types (one multiciliate and one uniciliate) of sensory cells which are interrelated by supporting cells with secretory activity. Due to the similarity of the external structure it can be hypothesized that enchytraeid sensory buds also have the same internal structure as is described for earthworms.

Especially those organs located in the oral cavity and on the prostomium of the Oligochaeta investigated seem to be associated with tactile and chemical stimuli; i.e. their main function seems to be gustatory. Organs on other parts of the body are probably mechano- and/or chemoreceptors. However, the functioning of the oligochaete sensory buds in detail remains unclear. This is especially true for the enchytraeids where up to now no physiological investigations have been done. Since no obvious differences were observed between the five studied species (representing five genera), it would be interesting to investigate one enchytraeid species in detail. As a first step, the ultrastructure of the sensory buds should be analysed with transmission electron microscopy to develop a testable hypothesis as to which sensory modality they serve.

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